

on the march from the Indus to the Tigris, by H. W. Bellew, C.S.I., Surgeon to the Bengal Staff Corps. "The Rod in India;" being hints how to obtain sport, with remarks on the natural history of fish, otters, &c., and illustrations of fish and tackle, by H. S. Thomas, F.L.S., F.Z.S. A third and enlarged edition of the "Celt, the Roman, and the Saxon," a history of the early inhabitants of Britain, down to the conversion of the Anglo Saxons to Christianity, illustrated by the ancient remains brought to light by recent research, by Thomas Wright, M.A., F.S.A.

A DEPUTATION from the Trades' Guild of Learning waited on Tuesday afternoon on a Sub-Committee of the London School Board, at the invitation of the School-Management Committee, in order to urge upon the Board the adoption of systematic training in mechanics, &c., with the object of adapting the scientific instruction, provided or contemplated in the Board schools, to the future employments of the children. A memorial to the same effect has been presented to the Board, and is now under their consideration, in favour of the elementary teaching of applied science and art in the schools, in such a manner as to lay the foundation of a connected system of technical education.

NEWS has been received of the death at Quito, Ecuador, in June last, of Dr. William Jameson, an eminent naturalist, who resided for many years in Quito as a professor of chemistry and botany in the University. His contributions, both in zoology and botany, to public institutions in America and Europe have been very extensive.

DR. DAVID MOORE reprints from the "Proceedings of the Royal Irish Academy" a complete Muscology of Ireland, under the title "Synopsis of all the Mosses known to inhabit Ireland up to the present time."

THE additions to the Zoological Society's Gardens during the past week include two Black-headed Parrots (*Caica melanocephala*) from Demerara, presented by Judge Lovesy; a Brown Bear (*Ursus arctos*), European, presented by Mr. M. B. Wilson; a Thickknee (*Oedienemus crepitans*), British, presented by Mr. Patey; a Lesser Black-backed Gull (*Larus fuscus*), British, presented by Mr. C. W. Wood; a Hairy Armadillo (*Dasyurus villosus*), from River Plate; a Burrowing Owl (*Pholoeptynx cucullaria*), from the same place, deposited; a Wattle Crane (*Grus carunculata*), from Africa, and two Bataleur Eagles (*Helotarsus ecaudatus*).

THE BRITISH ASSOCIATION

SECTIONAL PROCEEDINGS

SECTION A.—MATHEMATICS AND PHYSICS

On Etherial Friction, by Prof. Balfour Stewart, LL.D., F.R.S.

Professor J. C. Maxwell has made a series of experiments on the friction of gases. In these experiments a horizontal disc was made to oscillate in an imperfect vacuum near a similar disc at rest, and it was found that the motion of the oscillating disc was carried away by the residual gas of the vacuum at a rate depending on the chemical character of the gas, and depending also upon its temperature, but nevertheless independent of its density.

While the temperature of the arrangement remained constant, it was found by Prof. Maxwell that this fluid friction was rather greater for atmospheric air than for carbonic acid, while for hydrogen it was, I think, about half as great as for air.

On the other hand, when the temperature was made to vary the result was found to be proportional to the absolute temperature.

These experiments do not show that there is no such thing as etherial friction, that is to say, friction from something which fills all space, and is independent of air; but we may argue from them that such an etherial friction must either have been nearly insensible in these experiments, or it must, as well as the friction from the gas, have varied with the absolute temperature, in

which case the two frictions would not be separated from one another by the method of the experiment.

Prof. Tait and myself have made some experiments upon the heating of a disc by rapid rotation in vacuo. In these experiments we found a mere surface heating due to air which varied not only with the quality, but also with the quantity of the residual gas; and we also found a surface effect (more deeply seated however than the former), which appeared to be a residual effect, and which it is possible may be due to etherial friction. We made no experiments at varying temperatures, but we made use of various residual gases, and we found that the heating effect for carbonic acid was perhaps a trifle less than for air, while that for hydrogen appeared to be about four times less than that for air. Now comparing Prof. Maxwell's experiments with ours, we have in the former a stoppage of motion which is rather less for carbonic acid than for air, and about half as large for hydrogen as for air. In the latter again we have a heating effect rather less for carbonic acid than for air, and only about one-fourth as large for hydrogen as for air. Thus it appears that the stopping effect of hydrogen in Prof. Maxwell's experiments is relatively greater in comparison with air than is its heating effects in our experiments, when compared with that of air. The effects of these various gases would bear to one another more nearly the same proportion in both experiments, if we might suppose that in Prof. Maxwell's experiments there was mixed up with gaseous friction a very sensible etherial friction; but in that case it would be necessary to suppose that the etherial friction was proportional to the absolute temperature.

During the meeting of the British Association at Edinburgh, I brought before this section reasons for imagining that if we have a body in visible motion in an enclosure of constant temperature, the visible motion of the body will gradually be changed into heat. The nature of the argument was such as to render it probable (although not absolutely certain) that in such a case the rapidity of conversion will be greater the higher the temperature of the enclosure.

I will now refer to some experiments by Prof. Tait which formed the subject of the last Rede Lecture. These experiments were suggested to Prof. Tait by an hypothesis derived from the theory of the dissipation of energy which led him to think that the resistance of a substance to the conduction of electricity, and also of heat, would be found proportional to the absolute temperature. Mattiessen and Von Bose in the case of electricity, and Principal Forbes in the case of heat, had already proved that as a matter of fact the law was not very different from that imagined by Prof. Tait. The result of these experiments has been to confirm the truth of this law.

The following considerations also connected with the dissipation of energy point to the same conclusion. Perhaps we may regard the etherial medium as that medium whose office it is to degrade all directed motion, and ultimately convert it into universally diffused heat, and in virtue of which all the visible differential motion of the universe will ultimately be destroyed by some process analogous to friction.

Now in order to imagine the way in which either may possibly act in bringing about this result, let us imagine some familiar instance of directed motion, as for instance a railway train in motion. The train, let us suppose, and the air in it, are both in rapid motion, while the air outside is at rest. Now as the train proceeds, suppose that a series of cannons loaded with blank cartridges are fired towards the train. A series of violent sounds will go in at the one window, and out at the other of each carriage. Each sound will push some air from the stratum of air at rest into the carriage on the one side, and it will push some air from the carriage into the stratum at rest on the other side. Now in this operation it would seem that part of the visible motion of the train must be taken from it. To make another comparison, it is as if a series of individuals were jumping into the train at the one side, and out of it at the other, the result being that each carries away so much of the motion of the train, and therefore renders it difficult for the engine to drive the train. Each individual comes to the ground with an immense forward impetus, and rubs along the ground till this is lost; in fact, he carries with him so much motion of the train, and converts it into heat by friction against the ground.

Now something similar to this must happen to a substance in visible motion in an enclosure of constant temperature. The rays of light and heat will play very much the same part as the waves of sound, or as the crowd of people in the above illustration, at least if we except those which fall perpendicularly

upon the surface of the moving body. The moving body is like the train, and the rays of light and heat are similar to individuals entering the train from a stratum of ether at rest, and leaving the train into a stratum of ether at rest again, each probably transmuting into heat a certain small portion of the visible motion of the train as it were by a species of friction. Of course the intensity of such an influence would depend upon the intensity of the rays of light and heat. Now it matters not what the particular kind of motion be which constitutes this train—we may assert that all directed motion will suffer from such a cause, and possibly according to the same laws. Visible motion, such as that of a rotating disc, or of a meteor, is of course one form of such motion; but a current of electricity or of heat may equally represent some form of directed motion. In fine, we may perhaps suppose that all forms of directed motion are resisted by this peculiar influence, which evidently depends upon what we may term the temperature of the ether, or at least upon the intensity of those vibrations which the ether transmits.

On a Periodicity of Cyclones and Rainfall in connection with the Sunspot Periodicity, by Charles Meldrum.

At the Brighton meeting (1872) it was stated that the cyclones of the Indian Ocean between the Equator and lat. 25° S., were much more frequent during the maxima than during the minima sunspot years. Since that time the subject has been more fully examined, and I now beg to present a catalogue of all the cyclones known to have occurred during the last twenty-six years. The Tables given last year only contained cyclones of sufficient violence to dismast or otherwise disable vessels at sea, whereas the accompanying Catalogue gives all the cyclones of force 9 to 12, that is, "strong gale" to "hurricane."

The number of cyclones for each year from 1847 to 1873, is as follows:—

	Years.	No. of Hurri- cans.	No. of Storms.	No. of Whole Gales.	No. of Strong Gales.	Total No. of Cyclones.	No. of Cyclones in Max. and Min. Periods.
Max. {	1847	5	0	0	0	5	26
	1848	6	2	0	0	8	
	1849	3	2	3	2	10	
	1850	4	3	1	0	8	
	1851	4	2	1	0	7	
	1852	5	0	3	0	8	
Min. {	1853	1	1	5	1	8	13
	1854	3	1	0	0	4	
	1855	3	2	0	0	5	
	1856	1	0	2	1	4	
	1857	2	1	1	0	4	
	1858	3	1	3	2	9	
Max. {	1859	3	2	6	4	15	39
	1860	7	4	2	0	13	
	1861	5	2	2	2	11	
	1862	4	2	2	2	10	
	1863	5	2	1	1	9	
	1864	2	2	1	0	5	
Min. {	1865	2	2	3	0	7	21
	1866	1	4	2	1	8	
	1867	0	4	2	0	6	
	1868	3	2	2	0	7	
	1869	3	1	3	2	9	
	1870	2	1	5	3	11	
Max. {	1871	3	2	3	3	11	36
	1872	6	5	1	1	13	
	1873	4	5	3	0	12	

The observations for the years 1847-1850, are probably not so complete as those for the subsequent years during which the Meteorological Society of Mauritius made it a special duty to collect storm statistics. Still it is evident that not only the years 1860 and 1872, but also the year 1848, were remarkable both for the number and violence of cyclones, while the years 1856 and 1857 were quite the reverse. By taking the number of cyclones in each maximum and minimum sunspot year, and in each year on either side of them, so as to form maxima and minima periods of three years each, we obtain the results given in the last column of the above table, showing that during the

maxima periods 1848-1850, and 1859-1861, the number of cyclones was 65, whereas in the minima periods 1855-1857, and 1866-1868, it was only 34, or little more than one half. In 1856, there was only one hurricane of small extent, and in 1867, no hurricane at all. Indeed it is doubtful whether several of the cyclones in those years classed under "storms," should not have been put down in the columns of "whole gales" and "strong gales."

As, during the last twenty-two years, information respecting the hurricanes of the Indian Ocean has been carefully and systematically collected and tabulated, I believe that the results now given are substantially correct, and it seems to me that they point unmistakeably to a close connection between sunspots, or solar cyclones, and terrestrial cyclones, or what might be called earth-spots, by an observer, on another planet.

Most of the severest cyclones have already been traced, and the others will also be traced. When this shall have been done, an attempt will be made to express numerically the amount of cyclonic area and cyclonic force for each year. The catalogue gives little more than the number of cyclones, but from what is already known, there is little doubt that their extent and force were also far greater in the maxima than minima years.

Being desirous of extending the investigation as far back as possible I have been examining the lists of former hurricanes, and it is interesting to find that the evidence from this source strongly corroborates the correctness of the conclusions deduced from the observations of the last twenty-six years. From a "chronological table" published in the "Mauritius Almanack" of 1869, we obtain the following list of Mauritius hurricanes:—

Years	No. of hurricanes	Years	No. of hurricanes
1731	1	1818	1
1754	1	1819	2
1760	1	1824	2
1766	1	1828	1
1771	1	1829	1
1772	1	1834	1
1773	1	1836	1
1786	1	1844	1
1806	1	1848	1
1807	2	1850	1
1815	1		
Total		24	

Probably the above list gives only the hurricanes that were remarkable from their destructive effects in the island; and much stress should not be laid on observations taken at a single locality. But it is rather suggestive that out of the twenty-four hurricanes mentioned, seventeen fall within, or very nearly within, maxima sun-spot periods, and only seven within minima periods. Thus:—

Max. Years	No. of hurricanes	Min. Years	No. of hurricanes
1760	1	1731	1
1771	1	1754	1
1772	3	1766	1
1773	1	1824	2
1786	1	1834	1
1806	3	1844	1
1807	3		
1815		Total	7
1818	4		
1819			
1828	2		
1829	2		
1836	1		
1848	2		
1850	2		
Total		17	

The same "chronological table" contains the following remarks:— 1760, Dec. 1, "Meteorological Phenomena," 1815, Feb. 5, "Meteorological Phenomena."—I have not ascertained what these phenomena were; but it is not improbable that they were auroras. The aurora of the 4th Feb., 1872, was described in the newspapers as a *phénomène météorologique*.

Baron Grant, in his History of Mauritius, p. 194, regrets the destruction of the woods near Port Louis, because, he says, the town was thereby "exposed to the violence of the winds, as well

as to the heat of the sun;" and in a foot-note it is remarked: "These inconveniences, however, are fully counterbalanced, if it be true that the cessation of hurricanes since 1789 has been caused by the great diminution of the woods." As the history was published in or after 1801, it would appear that during the twelve years 1789-1801 no hurricanes occurred. Now, since according to the Table of Sunspots the years 1788 and 1804 were maxima years, and the intervening minimum occurred in 1798, our theory would lead us to expect a comparative cessation of hurricanes during the period mentioned.

If time permitted, I would adduce similar evidence respecting the hurricanes of Bourbon and other parts of the world.

The hurricanes of the Indian Ocean are well known to be attended with torrential rains. So much is this the case that the popular belief at Mauritius is that cyclones are the cause of our rains. Heavy rains over extensive areas are certainly concomitant with cyclones in the Indian Ocean, and it was therefore resolved to examine whether there was a rainfall periodicity. As far as the Mauritius observations went, the matter was clear; but it was desirable to extend the investigation to other localities. The Queensland and South Australia observations, which were the only ones available at the time, gave a similar result, and as Adelaide is far beyond the limits of the region of cyclones, it was surmised that there was a rainfall periodicity generally. The Cape observations afterwards gave additional support to this view. The rainfall of England was next examined, and also found to bear out the hypothesis.

It would occupy much more time than I can at present spare to enter fully into this question of rainfall periodicity. With the help of the researches of Mr. Lockyer, Mr. Symons, and Dr. Jelinek of Vienna, I have now examined 93 tables of rainfall for various parts of the world, and I find that, scarcely without exception, more rain falls in the maxima than in the minima sunspot years. I beg to append a table showing the general results for the quarters of the globe. It will be seen that, so far as the observations go, Europe, Africa, America, and Australia give very favourable results. Asia is only represented by three stations, one of which is Jerusalem, where the excess of rain in one minimum period exceeds the excess in the maxima periods for two stations in India. France is the only European country (of which the rainfall has been examined) that gives an unfavourable return, but it must be remarked that we have as yet got only five stations there, which are all inland, and probably do not fairly represent the rainfall of the whole country.

By taking the longest possible series of observations for several stations, the periodicity comes out, and there is, I think, strong evidence that the rainfall for the whole globe is subject to an annual variation.

Having given the facts, as far as I have been enabled to do so, I abstain from offering any theoretical remarks. If cyclone and rainfall periodicities be fully established, a corresponding (direct) temperature periodicity should exist, and this presumable variation of solar heat may be the indirect cause of the periodicity of auroras and magnetic disturbances.

(The catalogue of cyclones was appended.)

On the Effect of Pressure and Temperature on the Widening of the Lines in the Spectra of Gases, by Arthur Schuster, Ph. D.

One of the questions in Spectrum Analysis yet open to discussion, is what influence pressure and temperature exert on the widening of the lines, which is sometimes observed when an electric current passes through certain gases. The subject of this communication is to point out a little ambiguity which has crept into the very statement of the question at issue, and to show the only way by which a decisive answer can be arrived at, and, in my opinion, has already been arrived at. I shall begin by assuming that the convection of electricity has no direct influence on the character of the spectrum; that is to say that under the same pressure, and at the same temperature, the gas will always show the same spectrum, whether the temperature has been produced by the passage of an electric current or by any other means. In the present state of science this is the only reasonable assumption that can be made, and it has been tacitly made, I think, by every one who has written on the subject.

Let us imagine a vessel filled with hydrogen, and let the temperature of the gas be brought up to incandescence. The heat communicated to the vessel is partly used to increase the translatory motion of the gas, and thereby to increase its pressure, and the other part of the heat has increased the periodical motion in the molecules of the gas, which is generally admitted to be the cause of its incandescence. If the temperature is

such that the lines are widened we can account for this fact in two different ways. We may think that the forces which maintain the molecule in vibration, and which are such that at a lower temperature only perfectly isochronous vibrations can take place are somewhat altered, so that the bonds which keep the molecules together are loosened and now allow vibrations to take place, the period of which is somewhat altered and varying. We might secondly explain the widening of the lines by saying that they are caused by the disturbances caused by the frequent shocks of other molecules. If we increase the number or the force of these shocks by increasing either the number of molecules or their velocity we might well obtain disturbances large enough to change a little the period of vibration. These are the only two explanations that can be given, and if we say, therefore, that temperature is the cause of the widening of the lines we can only mean that part of temperature which has its equivalent in the vibrating energy within one molecule. If we say that pressure is the disturbing cause we include that part of heat which increases the pressure with increasing temperature. Let us now see whether we can obtain a clear answer to the question which has now been ~~dearly~~ put.

It is evident that no result can be arrived at by subjecting the same quantity of gas in the same vessel to different temperatures, for we cannot increase the vibrating energy of the molecules without increasing at the same time and in the same proportion (as Clausius has shown), their translatory velocity. By varying in the same ratio the two possible causes we shall never be able to say which is the right view to be taken.

There are two ways open to us to mend this difficulty. We might increase the temperature of the gas under the same pressure. If the perturbation caused by the shocks of other molecules cause the widening of the lines this widening ought not to take place as we have reduced the number of these shocks in the same ratio as we have increased their force. If on the contrary the disturbance in the period of vibration has its cause within the individual molecules it ought to remain.

We might, secondly, decide the question in subjecting the gas at the same temperature to different pressures. If perturbations are the cause the lines would be widened. Which of these two ways is most easily pursued in experimenting? Can we easily heat up a gas to incandescence under constant pressure? I think not. If an electric discharge takes place in a gas only comparatively few particles of the gas are heated up, and at a very small distance from the points through which the discharge takes place the gas is hardly heated up at all. But if the heat is not diffused through the whole mass of gas, the increase of pressure caused by this gas will also be merely confined to the luminous streak, and we can therefore obtain no answer to our question (as this has been attempted) by filling a tube with a certain quantity of gas, and altering the strength of the passing current or the mode of discharge.

We are, therefore, compelled to abandon this route and to turn our eyes to the second way which I have indicated; but here we meet another difficulty, and even one over which we cannot easily get. We cannot alter the pressure of a gas without altering its electric resistance, and, therefore, also the strength of the electric current and the heat developed. We can only decide the question by subjecting the gas at the same temperature to different pressure. Now have there ever been any such experiments made? I think there have, and even very decisive ones. Frankland and Lockyer have found that if we increase the pressure of hydrogen while an electric current is passing through it the lines begin to expand till the spectrum becomes continuous, and finally the resistance becomes so large that the electric current will not pass at all. On the other hand Gassiot and Plucker have observed that if we diminish the pressure of hydrogen its electric resistance force diminishes, attains a minimum, then increases again, and if we keep up exhausting the tube it becomes again so great that the current cannot pass. Plucker says that a tube exhausted to its utmost limits shows the lines of hydrogen and silica. He mentions at one place, I think, that the lines are very fine and distinct. If there would have been any widening he would have been sure to mention it. Now it is not too much to assume that the resistance of the gas at the moment when the discharge just ceases to take place is the same whether the increase of resistance is produced by too great a pressure or too great an exhaustion. At this moment, therefore, the current is the same and the same energy must be converted into heat by resistance. But in the case in which the current does not pass on account of the excessive diminution of pressure, only a much smaller

quantity of gas has to be heated than in the other case. It must, therefore, be heated up to a much higher temperature, and yet the spectrum is not continuous and the lines are not even widened. We are, therefore, compelled to accept Frankland and Lockyer's original conclusion, that pressure and not heat is the cause of the widening of the lines.

The question is one of considerable importance. If temperature would widen the lines, the widening ought always to begin at the same temperature, and the hydrogen in the solar protuberances which show only narrow lines could not be at a higher temperature than the hydrogen in our vacuum tubes, the moment the lines begin to widen. If our conclusion, however, is correct the breadth of the lines will give us no indication whatever as to the temperature of the gas.

Dynamometers, by R. S. Ball, LL.D., F.R.S.

If we adopt that force which acting on one gramme for one second will impart the velocity of one centimetre per second as the unit, then one million of such units is a convenient magnitude for practical purposes. The large figures on the dynamometers represent these million units, for which it is hoped that ere long a suitable name will be adopted. The dynamometers are intended for educational purposes. They are exhibited to the Association with the desire of aiding the present movement in favour of an improved system of fundamental unity.

SECTION C.—GEOLOGY

Concluding Report on the *Maltese Fossil Elephants*, by Dr. A. Leith Adams, F.R.S.

For thirteen years Dr. Leith Adams has prosecuted his researches upon the fossil elephants of Malta, and he now presented the final report upon this subject. Three forms of fossil elephants occur here which are unknown elsewhere, all of small size. The largest is the *Elephas Mnaidriensis* (L. Adams), which attained a height of seven feet. In the crown sculpturing of the molars this species resembles *Elephas antiquus*; as regards the ridge-formula, its nearest ally is *Loxodon meridionalis*. *Elephas Melitensis* (Falconer and Burck) varied in size; its average height was about five feet; this too belonged to the *Loxodon* group. The smallest bones known to the author belonged to an elephant only three feet high, called *Elephas Falconeri*, by Busk. Although there appears to be some evidence for separating this from the other forms, yet the author stated that "there is no difficulty in arranging a graduating series of specimens from the smallest up to the largest bones ascribable to the *Elephas Melitensis*."

The elephants all occur in the same deposit, and with them there are remains of *Hippopotamus Pentlandi* and *H. minutus*. There is also a gigantic dormouse and a large extinct swan, besides some reptilian remains not yet fully worked out.

The report concludes as follows:—"It must be apparent that this (for the most part) unique fossil fauna restricted to a small mid-ocean island, presents several interesting contrasts with reference to the Mammalia in general, and elephants in particular, which frequented Europe during late geological epochs. For example, between Rome and Sicily we find remains of the *Elephas primigenius*, *Elephas antiquus*, and *Elephas meridionalis*. In the caves of Sicily, traces of the African elephant have been discovered, and also molars, barely distinguishable from those of the Asiatic species, and which, under the name of *Elephas Armeniacus*, are traceable eastward into Asia Minor, in the direction of the present habitat of the living species. It looks, indeed, as if the eastern basin of the Mediterranean had been at one time a common ground where all these extinct and living elephants met, and from whence, with other animals, they have disappeared or been repelled to distant regions."

Sub-Wealden Exploration.—1. *General Report*, by Henry Willett.

In this report Mr. Willett gave a summary of the results achieved up to the present time, the details having already been published in his quarterly reports.

The boring was commenced at the time of the last meeting of the British Association at Brighton, and its object is to explore the rocks underlying the Weald of Sussex. A bore of 6½ inches diameter was at first adopted, but at the urgent recommendation of Mr. Prestwich, one of 9-inch diameter was employed. The bore has now reached a depth of 300 feet, and the engineer (Mr. Bosworth) has contracted to increase it to a

depth of 418 feet at the cost of only 1*l.* per foot. Of the 300 feet of strata already passed through, about 70 were previously known, but the remaining 230 are new to science; 50 feet of this consists of valuable beds of gypsum.

Mr. Willett has designed a novel form of drill which possesses the following advantages:—(1) It cuts only the circumference; (2) it makes better progress; (3) the central core is left intact; (4) the tool not unfrequently extracts the core itself. The gypsum was extracted by this means, and it is believed that no such cores have been brought to the surface from similar depths in this country.

Sub-Wealden Exploration.—2. *Geological Report*, by W. Topley, F.G.S.

The author commenced by repeating the protest, often made already, that the Sub-Wealden Exploration was not a "search for coal." It is simply an endeavour to explore the rocks which underlie the Weald and especially to reach the Palæozoic rocks. Whatever these rocks may prove to be, if reached at all, the boring will have succeeded. The results of this boring cannot fail to have important bearings upon the question of the probable occurrence of coal measures beneath the South-East of England, but the discovery of coal is not the object in view.

An account was then given of the lowest beds exposed at the surface in Sussex, and of the reasons which have led many geologists to consider them as representatives of the Purbeck Beds. The thickness of Purbeck Beds previously known in Sussex was somewhat over 300 feet; probably about 230 additional feet of strata have been made known by the boring, in which there are some valuable beds of gypsum.

The boring commences about 250 down in the known Purbeck Beds; up to Sept. 1 it had reached a depth from the surface of 294 feet. It is not safe at present to speculate upon the geological age of the lowest beds reached in our boring, but additional evidence will probably soon be obtained.*

The author then pointed out that most of the bore holes which have been put down to the Palæozoic rock through newer strata have reached those older rocks at about 1,000 feet below the sea. There is a probability then that at or about this depth the palæozoic rocks will occur beneath the Weald. These places, however, are on, or to the north of, the westerly prolongation of the Axis of Artois, whilst the boring is to the south of that line; it is therefore possible that different conditions may prevail here.

Attention was then drawn to the fact, already pointed out by Mr. Godwin-Austen, that the dip of the carboniferous limestone in the Boulonnais is to the south, whilst in the Pays de Bray the same limestone has been found at a depth of 57 feet from the surface, underlying Kimmeridge clay. It is then probable that under the secondary rocks near to the south of Boulogne there is a basin of palæozoic rocks, in which the coal measures may be preserved; this basin might possibly be prolonged to the west below the Wealden district of the south-east of England.

In the course of the discussion which followed the reading of these reports, Sir John Hawkshaw stated that many people, himself included, took an interest in this question chiefly from the hope that coal might be found; but even if in this respect we were doomed to disappointment it would still be of great importance to show that, at that particular spot, no coal existed. Prof. Phillips thought that the object sought was neither coal, gypsum, nor salt; but that *something* exists below the Wealden is certain, and that something we are now searching for. A discussion then took place as to the best mode of conducting deep borings. Mr. R. Russell, C.E., spoke of the great value of the diamond boring process; but from remarks made by other speakers it appeared that, although the diamond is admirably adapted for boring small holes in hard rocks, it is not so well suited for conducting such an operation as that under discussion.

On the Arenig and Llandeilo Rocks of St. David's, by Henry Hicks, F.G.S.

The object of this paper was to follow out the succession of the rocks in the neighbourhood of St. David's, commenced in previous papers communicated to the British Association. The section was now completed to the top of the Llandeilo series. The Arenig and Llandeilo groups were each divided into an upper and a lower series, the author believing that in each case

* Since this Report was read, Prof. Phillips has broken up and carefully examined parts of the cores brought up from the bottom of the boring; in them he has found *Lingula ovalis*, which occurs in the Kimmeridge Clay. (See p. 487.)

there was sufficient evidence to enable him to do so. The Lower Arenig series it was stated occur as black slates and flags about 1,000 ft. in thickness, and are characterised by many species of graptolites as well as by numerous trilobites entirely restricted to the series. The Upper Arenig series occur as fine-grained, soft black shales, not much cleaved, also about 1,000 ft. in thickness, resting conformably on the Lower Arenig series. Their graptolites are distinct from those found in the lower beds, as are also all the other fossils. The Lower Llandeilo series, the lowest rocks recognised by Sir R. I. Murchison in the typical Llandeilo district, occur at St. David's as black slates and hard grey flaggy sandstones, and are about 1,500 ft. in thickness. The most characteristic fossils are *Didymograptus Murchisoni*, *Diplograptus pristis*, *Asaphus tyrannus*, *Calymene Cambrensis*, and *Illenus perovalis*. The Upper Llandeilo series occur as black slates and flags, several thousand feet in thickness, forming several folds of strata, and resting conformably on the Lower Llandeilo series. The typical fossils are *Ogygia Buchii*, *Barrandeia Cordayi*, *Calymene duplicata*, *Cheirurus Sedgwickii*, *Trinucleus fimbriatus*, *Ampyx nudus*, and *Lingula Ramsayi*.

The author doubted whether any other spot hitherto examined in Britain could show so continuous a section of these rocks; still he believed that there was ample evidence to prove, from researches made in other parts of Wales and in Shropshire, that the succession here made out was, in most of its important details, capable of being applied to many other districts.

SECTION D.—BIOLOGY

DEPARTMENT OF ANTHROPOLOGY

On the Relation of Morality to Religion in the Early Stages of Civilisation, by Edward B. Tylor, F.R.S.

Investigations of the culture of the lower races of mankind show morality and religion subsisting under conditions differing remarkably from those of the higher barbaric and civilised nations. Among the rudest tribes a well-marked standard of morality exists, regulating the relations of family and tribal life. There also exists among these tribes some more or less definite religion, always consisting of some animistic doctrine of souls and other spiritual beings, and usually taking in some rudimentary form of worship. But, unlike the higher nations, the lowest races in no way unite their ethics and their theology. As examples, the Australians and Basutos of South Africa were adduced. The Australians believe spiritual beings to swarm throughout the universe; the Basutos are manes-worshippers, considering the spirits of deceased ancestors to influence all the events of human life, wherefore they sacrifice to the spirits of near relatives, that they may use their influence with the older and more powerful spirits higher in the line of ancestry. Yet these races and many others have not reached the theological stage at which man's good or evil moral actions are held to please or displease his divinities, and to be rewarded or punished accordingly. The object of the present paper is to trace the precise steps through which the important change was made which converted the earlier unethical systems of religion into ethical ones. This change appears to have been a gradual coalescence between the originally independent schemes of morality and religion.

In order to show the nature of such coalescence between religion and other branches of culture, not originally or not permanently connected with it, the author traced out on an ethnological line the relations between religion, and on the one hand the rite of marriage, on the other hand the profession of medicine.

First as to marriage:—The evidence of the lower races tends to show that at early stages of civilisation, marriage was a purely civil contract. Its earliest forms are shown among savage tribes in Brazil and elsewhere. The peaceable form appears well in the customs of the marriageable youth leaving a present of fruit, game, &c., at the door of the girl's parents; this is a clear symbolic promise that he will maintain her as a wife. Another plan common in Brazil is for the expectant bridegroom to serve for a time in the family of the bride, till he is considered to have earned her.

The custom of buying the wife comes in at a later period of civilisation, when property suited for trade exists. The hostile form of marriage, that by capture, has also existed among low tribes in Brazil up to modern times, the man simply carrying off by force a damsel of a distant tribe; the antiquity of this "Sabine marriage" in the general history of mankind being shown by its

survival in countries such as Ireland and Wales, where within modern times the ceremony of capturing the bride in a mock fight was kept up.

Now in none of these primitive forms of marriage, as retained in savage cultures, did any religious rite or idea whatever enter. It is not till we reach the high savage and barbaric conditions that the coalescence between marriage and religion takes place; as where among the Mongols the priest presides at the marriage feast, consecrates the bridal tent with incense, and places the couple kneeling with their faces to the east to adore the sun, fire, and earth; or, as where among the Aztecs the priest ties together the garments of the bridegroom and bride in sign of union, and the wedded pair pass the time of the marriage festival in religious ceremonies and austerities. So complete in later stages of culture did this coalescence become, that many have come to consider a marriage hardly valid unless celebrated as a religious rite and by a priest.

Second, as to the relation of the profession of medicine to religion. In early animistic philosophy, one principal function of spiritual beings was to account for the phenomena of disease. As normal life was accounted for by the presence of a soul operating through the body, in which it located itself, so abnormal life, including the phenomena of disease, was accounted for in savage and barbaric culture as caused by some intruding spirit. Thus spiritual obsession and possession becomes the recognised theory of disease, and the professional exorciser is the doctor curing disease by religious acts intended to expel or propitiate the demon. Since the middle period of culture, however, this early coalescence has been gradually breaking away, till now in the most civilised nations the craft of healing has become the function of the scientific surgeon or physician, and the belief and ceremonies of the exorcist survive in form rather than in reality.

By these cases it is evident that coalescence between religion and other matters not necessarily connected with it may take place at different periods of culture, and also that this coalescence may terminate after many ages of adhesion. Having shown this, the author proceeded to ascertain exactly when and how in the history of civilisation the coalescence of morality and religion took place.

First, where manes-worship is the main principle of a religion, as among some North American tribes and the Kafirs of South Africa, the keeping up of family relations strongly affects the morality. It is, for instance, a practice among the ruder races to disinter the remains of the dead or to visit the burial place, in order to keep the deceased kinsman informed as to what takes place in his family, in which he is often held to take the liveliest interest. Thus it is evident that any moral act of an individual damaging to his family would be offensive to the ancestral manes, whose influence must therefore strengthen kindly relations among the living members of the tribe. Higher in the social scale this ethical influence of manes-worship takes more definite form, as when in China the divine ancestor of an emperor will reproach him for selfish neglect or cruelty to his nation, and even threaten to induce their own highest divine ancestor to punish him for misdeeds. Thus amongst the ancient Romans, the Lares were powerful deities enforcing the moral conduct of the family, and punishing household crime.

Second, the doctrine of the Future Life begins at the higher levels of savagery to affect morals. In its first stage the doctrine of metempsychosis is seen devoid of moral meaning, men being re-born as men or animals, but when the distinction appears in the higher savagery between migration into vile or noble animals, it is not long before this distinction takes the form of reward or punishment of the good and wicked by their high or low re-incarnation, an idea which is the basis of the Buddhist scheme of retributive moral transmigration through successive bodies. In its earlier stages this doctrine was of mere continuance, as where South-American tribes expected the spirits of the dead to pass to another region where they would live as on earth. Here the distinctions of earthly rank are carried on, the chief's soul remaining a chief, and the plebeian's soul a plebeian, but no sign of moral retribution appears. The first stage of this seems to be where warriors slain in battle are admitted to the paradise of chiefs in the land of the Great Spirit. This idea, which comes into view in several districts, leads to the fuller moral scheme in which goodness of any kind—valour, skill, &c.—are more and more held to determine the difference between the next life of the good man in happy hunting-grounds, or of the bad man in some dismal wilderness or subterranean Hades. In

the higher nations this element becomes more and more distinctly marked, till the expectation of future reward and the fear of future punishment becomes one of the great motives of human life.

Third, when theology among the rudest tribes is mostly confined to consideration of ghosts, demons, and nature-spirits, the intercourse with these leads to little inculcation of moral action. It is when ideas of the great deities become predominant, when men's minds are turned to the beneficent action of the sun, or heaven, or earth, or to a Supreme Deity yet above these, that it is conceived that the order of nature includes moral order of human conduct. Then, as in the religion of ancient China, the universe and its Supreme Deity are regarded as furnishing the model and authority regulating man's actions towards his kindred and his subjects. Thus appears, not in the beginning, but in the middle of the development of religious ideas among mankind, the leading principle of a moral government of the world and its inhabitants.

In these three ways it appears from the evidence of ethnology that the vast transition was made from the earlier unethical to the later ethical systems of religion. Its course, so different from that imagined by the older speculative theologians, has to be ascertained from examination of the actual stages through which the religions of the world have passed. The very attempt to make this investigation on a basis of facts is, however, a novelty.

SCIENTIFIC SERIALS

THE *Monthly Microscopical Journal* commences with an article, illustrated with a plate, "On Organic Bodies in Fire Opal," by Mr. H. J. Slack, in which the author, from the appearances which he finds and describes, expresses an opinion, though not a decided one, that these minute bodies may be vegetable fossils, possibly algæ, though the evidence he adduces is extremely slight. Dr. G. W. Royston Pigott continues his researches on the high-power definition of organic particles, and re-affirms that the generally received description of the Podura scale is erroneous, on account of the employment of spherically over-corrected objectives.—Mr. Wenham criticises Dr. Pigott's paper in the preceding number of the *Journal*, remarking truly that the patience of microscopists must eventually become exhausted by the repetition of the same theme. He then shows that Dr. Pigott claims, without foundation, discoveries with regard to the improvement of object-glasses and the "colour test."—Dr. Maddox, On the apparent relation of nerve to connective-tissue corpuscles, &c., in the Frog-Tadpole's Tail, describes, in connection with the observations of Eberth, Kuhne, and Moseley, cases in which nerve-fibres seem to lose themselves in connective tissue corpuscles. His results are not very decided, and hardly tend to settle the question.—Mr. Edwin Smith describes a new sub-stage for the microscope, and certain appliances for illumination.—The paper read before the Royal Society, by Messrs. Pöde and Lankester, is given in full. Their experiments are divided into eight series, in which infusions of hay and turnip, mixed or unmixed, with cheese finely divided or in lumps, are boiled and some of them sealed. When the cheese was finely comminuted, Bacteria did not appear; when in lumps, they were frequently found. In a boiled turnip infusion, placed in a retort of which the end was left open, there was no cloud developed after many weeks, which is quite contrary to the observations of Dr. Bastian (*NATURE*, Feb. 6, p. 275.)

THE *Geological Magazine* contains Prof. T. Sterry Hunt's article from the *Canadian Naturalist*, on the history of the names Cambrian and Silurian in Geology. The subject is divided into three parts: 1. The history of Silurian and Upper Cambrian in Great Britain from 1831 to 1854. 2. That of the still more ancient rocks in Scandinavia, Bohemia, and Great Britain up to the present time. 3. The history of the Lower Palæozoic rocks in North America.—Mr. E. Hardman describes and gives analyses of the Siliceous Nodular Brown Hematite (Göthite) in the Carboniferous Limestone Beds near Cookstown, Co. Tyrone. The ore contains as much as 52.2 per cent. of iron, on the average, and no sulphur.—Mr. J. C. Mansel-Pleydell has a brief memoir on the geology of Dorsetshire, which is an interesting summary of the most important points in the unbroken series from the Liassic to the Quaternary formations found in the county.—Mr. Joshua Wilson, in endeavouring to arrive at the time when the Gulf Stream reached the British Coast and so dispersed the then abundant glaciers, ingeniously shows that a

raised beach, containing Arctic shells, mentioned by Geikie in his "Scenery of Scotland," must have been produced before that event, otherwise it would have been removed by the offshore under-current which always accompanies an onshore wind.—Dr. Winkler's description of *Pterodactylus micronyx* in the Jeyler Museum, from the Lithographic Stone of Eichstätt, in Bavaria. The specimen is very small and complete. There are four phalanges in the long finger of the hand. In the foot there are two in hallux; three on the second and third; and two, with no metatarsus, on the fourth (Stümmel).—In a letter to the editor, Mr. T. W. Danby, after comparing the new method of writing crystallographic formulæ proposed by Mr. Rutley, shows that it is not so advantageous as that of Dr. Whewell, modified by Prof. W. H. Miller; it is therefore doubtful whether its partial acceptance will not place a further obstacle in the student's path.

THE numbers of the *Journal of Botany* for August, September, and October, fully maintain the character of this magazine. In addition to the short notes and queries in each number, which often contain points of great interest to the systematic or physiological botanist, the following articles may be mentioned as of special value:—Dr. Alfred Nathorst, of the Geological Survey of Sweden, contributes a paper on the Distribution of Arctic plants during the Post-Glacial Epoch, which he considers to exhibit gradual changes of climate from the Forest-bed down to the Boulder-clay.—Prof. Church gives an analysis of the giant puff-ball, *Lycoperdon giganteum*, which he finds to contain, when dried, as much as 66.78 per cent. of albuminoids, and the ash 46.19 per cent. of phosphorus pentoxide.—Mr. J. G. Baker describes a very interesting new genus of ferns, *Diplora*, of the tribe *Aspleniez*, from the Solomon Islands.—From the same botanist we have a valuable synopsis of the East Indian species of *Dracana* and *Cordylina*.—Mr. J. Ball commences a description of some of the new species, sub-species, and varieties of plants collected by Dr. Hooker and himself in Morocco in 1871; the flora belongs essentially to the Mediterranean type, and the number of novelties is not comparatively large.—Mr. Carruthers gives his very valuable annual Review of the Contributions to Fossil Botany published in Britain in 1872, comprising 23 distinct papers or abstracts.—In these numbers we have also parts vi. and vii. of the Rev. E. O'Meara's Recent Researches in the Diatomaceæ.

THE second part of vol. xxix. of the *Transactions of the Linnean Society*, just published, is occupied by a continuation of Colonel Grant and Prof. Oliver's "Botany of the Speke and Grant Expedition." The number of new species described in this part is thirty-five; and it is illustrated by thirty-five full-sized 4to plates, the expense of which is munificently borne by Col. Grant.

Der Naturforscher, August.—The eruption of Vesuvius last year attracted much scientific observation, and we have in the present serial an abstract of a valuable paper by M. Heim on the nature and formation of lava, of which he distinguishes two kinds, "lump" lava and "cake" lava (*Schollen* and *Fladen*), differing, he found, not in chemical constitution, but merely in vapour-contents. In the physical division we may note M. Wiedemann's experiments in measuring the elliptical polarisation from reflection on bodies with surface colours, for a series of angles of incidence, and different parts of the spectrum. Meteorology is represented by M. Dufour's recent observations on reflection of solar heat from the Lake of Geneva; and an interesting paper entitled "Polar Lights and Earth Lights." There is a description of M. Zöllner's new mode of estimating the absolute temperature of the sun, which is based simply on a knowledge of the density relation between two different layers of the hydrogen atmosphere, the distance between them being known. The value his formula gives is 61350°. Among botanical subjects treated are, autumn colouring of leaves and formation of vegetable acids, summer dryness of our trees and shrubs, and passage of radiant heat through leaves. Some physiological experiments by M. Rosenthal, on the time-relations of reflex phenomena, are described; and there is a variety of other matter, much of which has already been noticed in these columns.

Annalen der Chemie und Pharmacie. Band. clxviii. Heft. 1, July 16.—The number opens with four papers by Prof. Ad. Claus, on azophenylene, on di-iodhydrin, on the action of ammonia on dichlorhydrin, and on the preparation of dichlorhydrin. The first of these contains a long and exhaustive account of the body in ques-